

CHAETOGNATHA,

WITH A NOTE ON THE VARIATION AND DISTRIBUTION OF THE GROUP.

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(With Plate XIII, and Text-figures 39 and 40.)

AMONG the pelagic organisms, collected by Mr Stanley Gardiner's Expedition in the Maldive Archipelago in the years 1899 and 1900, were considerable numbers of Chaetognatha. They were fished chiefly at night, in moderate depths, and were preserved directly in 4 per cent. formalin. They are divided into two parts, viz. some were collected between Dec. 10 and Jan. 10, and the rest in April. Those obtained in the winter were much more abundant both in individuals and species, the number of specimens submitted to me being about 900 in the winter months compared with rather over 250 in April.

In classifying the group I have followed Langerhans ("Wurmfauna von Madeira," *Zeitschr. wiss. Zool.* Bd. xxxiv. p. 132, 1880) and Strodtnann ("Systematik der Chaetognathen," *Archiv Naturgeschichte*, Jahrgang 58, Bd. i. p. 333, 1892), and have used the names *Sagitta*, *Spadella* and *Krohnia* in the sense which they have defined, viz.

Sagitta forms with two pairs of lateral fins, and two rows of teeth;

Spadella with one pair of lateral fins on the tail segment only, and two rows of teeth;

Krohnia with one pair of lateral fins extending on the trunk and tail, and one row of teeth.

The Chaetognatha from the Maldives include several species well known from European waters, and others which have been procured only from the American coast or from Japan, but a considerable proportion (6 species out of 15) appear to be undescribed. *Sagitta* is much the most abundant genus, but *Spadella* is represented by one moderately common species, while only two specimens of *Krohnia* were found.

In a Note at the end of the "List of the Species" I have added the description of a new species, found by the late Mr F. P. Bedford at Singapore.

I. LIST OF THE SPECIES.

I. Genus **Sagitta** Slabber.1. *Sagitta enflata* Grassi.

Strodtmann, *Archiv Naturgeschichte*, Jahrg. 58, Bd. I. p. 348, 1892.

This species is very abundant both in winter and in April, making up perhaps fifty per cent. of each collection. It agrees with Grassi's description in most points; the tail segment is however rather shorter in proportion to the trunk, and the teeth are sometimes more numerous. Exactly the same differences are described by Aida (*Annot. Zool. Jap.* Vol. I. p. 13, 1897) between the *S. enflata* found in Japan and those of European waters.

This species has been hitherto recorded from the Mediterranean, Madeira and Japan.

2. *Sagitta magna* Langerhans.

Strodtmann, *Archiv Naturgeschichte*, Jahrg. 58, Bd. I. p. 343, 1892.

Fairly abundant in the winter, but not found in April. Only a few specimens reached a length of 3 cm. Did not differ in any points from Grassi's and Strodtmann's descriptions.

Recorded hitherto from Madeira and the Mediterranean.

3. *Sagitta tricuspidata* Kent.

Strodtmann, *Archiv Naturgeschichte*, Jahrg. 58, Bd. I. p. 342, 1892.

A rather scarce species in the winter, and not found in April. It is the largest species found, some specimens attaining a length of nearly 4 cm. In shape it is like *S. magna*, but slightly narrower, and while the posterior fins of *magna* are nearly semicircular, those of *tricuspidata* are broader near their posterior ends. The ovaries are long and slender, and may extend to the front end of the anterior fins; the longest observed were 1.5 cm. in length. Hooks 4—8, anterior teeth 3, posterior 1; but in several specimens, making up a large proportion of the whole number, there were 2 anterior and either 2 or 4 posterior teeth. The posterior teeth are attached to a cuticular bar which bears a number of rounded projections. Such projections are commonly found in other *Sagittas*, corresponding in number and position with the teeth, and are in some cases sharply pointed, and in this species, although the teeth are reduced to very few, the projections remain, but are rounded off. A similar condition exists in *S. magna*. The corona ciliata is short, on the head and neck.

This species has very few distinguishing characters; it is separated from *magna* chiefly by the absence of the very long moveable teeth in the anterior row, and from *hexaptera* by the small number of posterior teeth, but when the latter are as numerous as four, it becomes difficult to separate them with certainty. The teeth seem to have been reduced, and are at present very variable, but the typical number for the species is three anterior and one posterior.

Recorded from the Pacific, the Atlantic, the Mediterranean and the Indian Ocean.

4. *Sagitta serratodentata* Krohn.

Strodtmann, *Archiv Naturgeschichte*, Jahrg. 58, Bd. 1. p. 347, 1892.

A moderately common species both in winter and spring. Some specimens had as many as 18—20 posterior teeth and 10 anterior, instead of 12 and 8 respectively as are normal in European waters.

Hitherto recorded from the Mediterranean, the Atlantic, and Japan.

5. *Sagitta hispida* Conant.

F. S. Conant, *Johns Hopkins Univ. Circ.* Vol. XIV. p. 77, 1896, and xv. p. 82, 1896.

This species was rather scarce in the material collected in the winter, but in that obtained in April it was very abundant. It is characterized by the thickness and solidity of the body-wall, the thickened ectoderm behind the head, the intestinal diverticula in the neck, and the great number of tactile prominences. The teeth in the specimens from the Maldives were sometimes more numerous than in Conant's description; Aida mentions the same fact in specimens from Japan. Corona ciliata long and waved; in one specimen I found it divided into two parts, an anterior and a posterior.

Described previously from the Atlantic coast of America, the West Indies, and Japan.

6. *Sagitta regularis* Aida. (Plate XIII, fig. 7.)

T. Aida, *Annot. Zool. Jap.* Vol. 1. p. 17, 1897.

Occurred in small numbers in the winter. This species is very small, rarely more than 5 mm. The tail is one-third of the length of the whole. The fins are narrow, semi-elliptical, and have rays extending to the base. The tail fin and the posterior lateral fin both touch the vesiculæ seminales, which are small. The ovaries extend to the anterior paired fins. The epidermis is thickened through the whole length of the animal, but very much so behind the head, so that there is no neck. The number of tactile prominences is very large, and they are arranged with great regularity. The intestine has diverticula at its beginning. Hooks 7, anterior teeth about 4, posterior about 6. Corona ciliata rather long, waved, with a constriction in the middle. It is shorter than that of *S. hispida*, and lies entirely on the trunk.

Hitherto recorded only from Japan.

7. *Sagitta flaccida* Conant.

F. S. Conant, *Johns Hopkins Univ. Circ.* Vol. xv. p. 82, 1896.

Only one specimen of this species was found, and it occurred in the collection made in April. The species resembles *S. enflata* very closely, but differs in the form of the teeth. There are seven or eight anterior and 10—12 posterior teeth, and they are longer and more slender than in *enflata*, and the inner ones, especially of the anterior row, are much longer than the outer.

Described only from the Bahamas.

8. *Sagitta robusta* nov. sp. (Plate XIII, figs. 1 A, 1 B.)

This species is abundant in the material collected in winter, but scarce in that obtained in April. It is characterized by the great thickness of the body-wall, especially of the longitudinal muscles.

The length of mature specimens is 1.6 cm. of which the tail segment makes up one-fourth. The head is broad; the anterior fin is as long as the posterior, but narrower, its front end is opposite the posterior end of the abdominal ganglion. Both posterior lateral fins and tail fin reach the vesiculae seminales. The fin-rays do not extend quite to the base of the fins. The epidermis is thickened behind the head. The corona ciliata is long and narrow, beginning in front of the eyes just behind the brain, and is in shape an elongated ellipse, without the cross-shape found in *S. bipunctata*. There is a pair of diverticula at the beginning of the intestine, like those in *S. minima*. The ovaries are extremely long, and extend in fully mature specimens to the anterior transverse septum, so that the coelom of the trunk becomes almost obliterated. The vesiculae seminales project somewhat. Hooks usually 8, with very small points; anterior teeth 9, posterior 10—14.

I have found this species also among Chaetognatha collected at Singapore.

9. *Sagitta ferox* nov. sp. (Plate XIII, fig. 2.)

A species closely resembling *S. robusta*, but distinguished by several constant differences. It is less abundant than the latter, and did not occur in the April collection.

The body-wall is very thick, with powerful muscles. The tail segment is rather more than one-fourth of the whole length, which is about 1.2 cm. The fins are almost as in *S. robusta*, but the posterior does not quite reach the vesiculae seminales, which project only slightly. The epidermis is slightly thickened behind the head. There are intestinal diverticula as in *S. robusta*, and the ovaries are extremely long, as in the latter, but they do not quite reach the front end of the trunk-cavity. Hooks 5, or sometimes 6, very thick and powerful, with rather blunt points; anterior teeth about 6, posterior 10, with blunt points and rather broad.

As will be seen from the above description, this species differs very slightly from the last, and should possibly be classed with it. In some points, however, there is a constant difference. There are never more than 6 hooks in *S. ferox*, and there are usually only 5, while in *S. robusta* there are 7 or 8, and the hooks of *ferox* are thicker and have larger point-pieces than in the other species. The teeth of *ferox* are also thicker and rather fewer in number. In no specimen was the corona ciliata found complete in *ferox*, but from the traces that remain it seems to resemble that of *robusta*. When preserved in formalin *ferox* always has a faint pink colour, while *robusta* is white or yellow, and is rather less opaque.

10. *Sagitta gardineri* nov. sp. (Plate XIII, figs. 5 A, 5 B.)

A moderately abundant species in the winter collection.

Length 2.5 cm. Body thick and transparent, resembling that of *S. magna*. Head broad and short. Tail segment one-fifth of length of whole. Fins like those of *S. magna*; the rays do not quite reach the base. Ovaries when mature rather long, extending to the posterior end of the anterior fin; they are thicker and shorter than in *S. magna*, but proportionately longer than in *S. enflata*. Vesiculae seminales spherical, placed at the front

end of the tail fin. Corona ciliata entirely on the head; pear-shaped, with the narrow end lying just behind the brain, in front of the eyes. Hooks 8—10; anterior teeth small, about 10; posterior larger, pointed, varying from 12 to 16.

This species is intermediate between *S. hexaptera* and *enflata* in size and in the form of the ovaries, and it differs from both in the larger number of teeth. Although it is closely connected with these two species, yet the differences are so constant that there can be no doubt of its distinctness.

11. *Sagitta pulchra* nov. sp. (Plate XIII, figs. 4 A, 4 B.)

A moderate number of this species occurred both in the winter and spring collections.

Its length is 2 cm., of which the tail segment makes up one-sixth. The body is slender, with a thin body-wall, so that this species is intermediate between the large, inflated, and the smaller muscular types of *Sagitta*. The head is small, and the epidermis somewhat thickened behind the head. The anterior fin begins at the abdominal ganglion, and is rather long, so as to be separated by a short distance only from the posterior. The front half of the anterior fin is very narrow and has no rays; the posterior part is rather wide. The posterior fin is like the anterior in shape, but the part without rays is shorter and that with rays wider. The rays do not extend quite to the base.

The ovaries are rather long and slender, the vesiculæ seminales small. The whole of the tail coelom is filled with developing spermatozoa. The corona ciliata is moderately long; it begins in front of the eyes and rather more than two-thirds of its length is on the trunk; it is narrow and its sides parallel. Hooks 6, rather curved and slender; anterior teeth about 6, posterior about 10.

This species is of interest in combining the characters of two groups of *Sagitta*, viz. the larger species, which have a thin body-wall, short corona and in which only part of the tail coelom is filled with developing sperm; and secondly the smaller species with thick body-wall, long corona and tail full of sperm-morulae.

12. *Sagitta polyodon* nov. sp. (Plate XIII, figs. 3 A, 3 B.)

Found in fair abundance in both winter and spring.

This species is superficially very like *S. serratodentata*. Its length is about 1.2 cm., the tail one-fourth of the whole. The shape is that of *serratodentata*. The fin-rays spring from the base of the fins. The ovaries are long, extending to the anterior fins. The vesiculæ seminales are rather large and projecting. The hooks are 6—7, with no serrations; anterior teeth 9—10, posterior 26; they are slender, truncated at the end, with small processes. The corona ciliata is long and rather wider just behind the neck than elsewhere.

This species is distinguished at once by the great number of its teeth, which are more numerous than in any other known species. It resembles Béraneck's description of *S. bedoti*¹ in many ways, but differs in having a corona, in the length of the ovaries, and the greater number of teeth. Since Béraneck described *S. bedoti* from preserved specimens, in which the corona is often destroyed in one species while well-preserved in

¹ E. Béraneck, "Chétognathes de la baie d'Amboine," *Rev. Zool. Suisse*, Vol. III. p. 147, 1895.

others, it is possible that in this point he was mistaken; but, since the absence of the corona is a definite part of the diagnosis of *S. bedoti*, the present species cannot be identified with it.

13. *Sagitta septata* nov. sp. (Plate XIII, fig. 6.)

Moderately common both in winter and in spring.

It is a small species, generally less than 1 cm. The tail segment is a third of the whole. The fins are narrow, especially the anterior. There is no epidermal thickening behind the head, but the body-wall as a whole is thicker in the posterior part of the trunk than anteriorly. There are intestinal diverticula like those of *S. minima*. The vesiculæ seminales are very small. The ovaries are long, extending to the ventral ganglion, and the ova have a very curious appearance in fully adult specimens. They become pressed together so that they are flattened anteriorly and posteriorly, and the flattened faces have the appearance of septa dividing the trunk into a series of compartments on each side.

In no specimen was the corona well preserved, but it could be seen from the fragments remaining that it lies both on the head and on, at least, the beginning of the trunk. Hooks 6—8, anterior teeth 6—8, posterior 13—16, rather narrow and pointed.

The most prominent characteristic of this species is the peculiar structure of the ovaries (Plate XIII, fig. 6 and Text-fig. 39). The eggs appear to have their shells well developed, and the "septa" are due to the shells of two eggs being pressed together. In section it appears that when the eggs assume this condition they are already in the oviduct, which is greatly dilated, for when followed back the cavity containing the eggs is found to open at the usual pore of the oviduct; this view is supported by the fact that the large eggs lie at the outer sides of the ovaries, next to the body-wall, and that no other oviduct is visible, and further that the usual germinal epithelium appears between the large eggs and the alimentary canal. The animals appear to be undergoing histological degeneration, for the alimentary canal has lost its lining cells for the most part, and through the greater part of the body is much reduced in size. A condition comparable with this is frequently found in *S. minima*. A very similar arrangement of the eggs occurs in a fully adult *Krohnia pacifica* in Mr Gardiner's collection, so that it is not quite peculiar to *Sagitta septata*.



FIG. 39. Transverse section of *Sagitta septata* in the region of the ovaries. The ripe eggs are represented by oval bodies (dotted) lying in spaces which are probably the enlarged oviducts. The germinal epithelium is seen lying at the inner side of each of these spaces, connected with the alimentary canal by a mesentery.

II. Genus *Spadella* Langerhans.

14. *Spadella draco* Krohn.

Strödtmann, *Archiv für Naturgeschichte*, Jahrg. 58, Bd. I. 1892, p. 356.

This species was plentiful in the winter but did not occur in the summer. It agrees in every way with the published descriptions. I found a number of specimens in which the remarkable parenchymatous tissue was entirely absent, and was at first inclined to regard them as a new species, but afterwards found some in which part of the parenchyma

remained, showing that it had become detached during preservation or in transit. Some of the best-preserved specimens have a bright yellow colour in formalin, while others are colourless.

This species has been previously recorded from the Mediterranean, both sides of the Atlantic, Java and Japan.

III. Genus *Krohnia* Langerhans.

15. *Krohnia pacifica* Aida.

T. Aida, *Annot. Zool. Jap.* Vol. I. p. 19, 1897.

Only two specimens of this species were obtained; one in the winter and one in the April collection. It is only 7 mm. in length, but the ovaries show it to be mature. In the specimen taken in April the latter had large eggs (text-fig. 40), pressed together as described above in *Sagitta septata*. The tail is a third of the whole length. Both tail-fin and lateral fin meet the vesiculae seminales, which are ovoid. The tactile prominences have very long bristles. Hooks 9, pointed, with very small end-pieces. Teeth 13, very long; the row of one side meets that of the other side. The eyes are very near together.

There can be no doubt that this is the *Krohnia pacifica* described by Aida; the teeth are slightly more numerous, and the green colour which he mentions is not visible in preserved specimens. He describes the mouth as a transverse slit, but this appears to me to be due to a sort of lip overhanging the mouth anteriorly; the true mouth is as usual longitudinal.

Previously described only from Japan.

[NOTE. ON SOME CHAETOGNATHA FROM SINGAPORE.]

I include here the description of a new species of *Sagitta* obtained by the late F. P. Bedford at Singapore. It was accompanied by a few specimens of *S. enflata* and *S. robusta*. There was only one specimen, which is not fully mature; the condition of the ovaries however shows that it is not very young.

Sagitta bedfordii nov. sp.

Very small; an individual apparently nearing maturity, measures only 3.5 mm. Tail one-third of whole. Fins narrow, with rays springing from the base and placed unusually far apart. Corona ciliata imperfectly preserved, but lying both on head and trunk, and apparently short and pear-shaped. Body-wall thick, with epidermal thickening behind the head. Hooks 10, anterior teeth 2, posterior 2, all, especially the anterior ones, long, narrow and pointed, like those of *S. magna*.

The number and shape of the teeth is sufficient to distinguish this species at once from all the other small species.]

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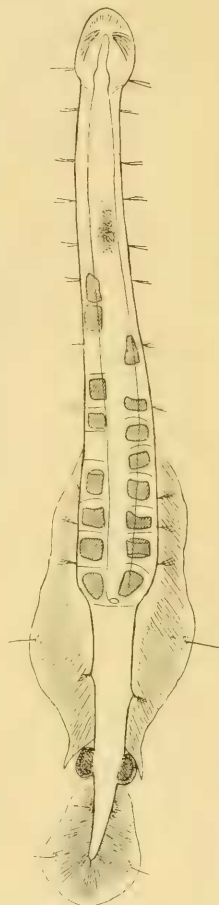


FIG. 40. *Krohnia pacifica*. A specimen taken in April, which has a number of ripe eggs on each side arranged with their shells in contact, giving the appearance of transverse septa. These eggs, as in *Sagitta septata*, are probably in the oviduct.

II. VARIATION AND DISTRIBUTION OF THE GROUP.

The examination of the specific characters and the geographical distribution of the Chaetognatha leads to several points of interest. In the first place, it is found that most species are world-wide in their distribution, and are obtained in almost all the warmer seas; only a few species have been observed in very limited areas, and since *Sagitta flaccida* and *S. regularis*, which had hitherto been recorded only from the West Indies and Japan respectively, have now been found also in the Indian Ocean, it seems probable that some, if not all, the remaining local species will be known eventually to have a wider range.

Individuals of the same species have as a rule the same characters in whatever part of the world they occur, but there are a number of exceptions to this rule; for example, the *S. serratodentata* from the Maldive Group had usually a greater number of teeth than those of the Mediterranean, and Aida records the same fact in respect of several species from Japan. But the characters, which are used to distinguish the species of the Chaetognatha, are very variable in themselves, so that examples from the same locality differ considerably from one another, and it is sometimes a matter of difficulty to determine these species with certainty; for example, the individuals described above as *S. tricuspidata*, which have an arrangement of teeth different from that of the type, might be referred to *S. hexaptera*, in which the teeth were fewer than the normal, and so in other cases.

In fact, it almost seems that the species in the Chaetognatha are not very definitely fixed, but graduate into one another to some extent, although they can be separated into several groups, which are very distinct; for example, *Sagitta hexaptera*, *S. tricuspidata*, *S. magna* and *S. lyra* form a well-marked group of large species, which can be separated at a glance from the type represented by *S. hispida* and *S. regularis*.

The question of species in the Chaetognatha is an interesting one from the point of view of evolution, for in most seas a great number of individuals of various species are found together but all having, as far as we know, similar habits and living mingled together. Geographical isolation or differences of habitat apparently do not exist, and probably most species breed through the greater part of the year, so that there can be no separation by differences of breeding season.

In many instances two species, living together, are so closely allied that it is very difficult to distinguish them, in which case it seems hardly possible that the separation can have been due to natural selection. Possibly the great variety of Chaetognatha found together, all living under the same conditions and with similar habits, may be best explained by supposing the species to be very ancient, and that the different species have arisen in different parts of the world and have become spread by currents or other means of dispersal, until they are found in all the seas where the temperature is sufficiently high. The characters by which the species are distinguished, such as hooks, teeth, proportions of the body and fins, etc., are very variable within certain limits, as has been shown above. If, then, a part of the ocean became partly or wholly separated from the rest by geological changes, in the course of time this variability would undoubtedly cause the fauna, so cut off, to become different from the remainder, and, when they again became intermingled, they would be classed as different species. The Chaetognatha offer this problem in a

peculiarly prominent manner, for there are few other groups of animals of which as many as ten or even more species of one genus are found together in exactly the same environment.

The question of the nature and extent of the variation in each species is also of interest, for there are indications that the characters commonly relied upon as distinctive may sometimes be very untrustworthy. It has been pointed out how in some species local races exist with slightly different characters, as in the case of *Sagitta serratodentata* and *S. hispida*, but some species are markedly variable in the same locality. For example, besides the variation in number of the teeth in *S. tricuspidata* mentioned above, it was found that while the typical number of hooks is 8, one specimen had only 4, another 5, and others 7 on each side.

I observed a more remarkable case of this at Naples, which possibly indicates that the hooks are lost to some extent at maturity. The species in question was *Sagitta lyra*, which Grassi in his monograph (*Fauna et Flora des Golfes von Neapel*; I Chetognati) describes as being very rarely found sexually mature, while immature specimens are comparatively common. At Naples during the early spring of 1901 immature specimens were frequent in the "Auftrieb" from no great depth, and many were of considerable size, e.g. as much as 28 mm. with only most minute rudiments of ovaries and testes, and no trace of genital ducts. In April, however, a number of specimens were caught in the neighbourhood of Capri at depths of 400 and 1000 metres, and these were mostly sexually mature. Those from the greater depth were remarkable in that a large proportion had only three hooks on each side instead of seven, although others were nearly or quite mature with the normal seven hooks. These examples had otherwise all the characters of *S. lyra*, except that the head was perhaps shorter and broader than usual.

These facts seem to indicate that either there are two closely allied species or varieties included under the name *S. lyra*, or that when maturity is reached, four out of the seven hooks on each side are, in some cases at least, lost. It also seems to suggest that when mature this species migrates to a much greater depth, for no fully adult specimens were taken at the surface. Grassi did most of his work at Messina, where the currents bring up to the surface animals which normally live in deep water, and this probably accounts for his finding occasional adult specimens.

With regard to variation in different localities, it appears that most of the widely distributed species differ to some extent in widely separated areas, as is mentioned above in respect to the teeth. It is interesting to note that in all cases in the present collection, where the teeth differed in number from those of the European variety, they were more numerous, so that the average number of teeth in specimens from the Indian Ocean is considerably greater than from Europe. Another character which distinguishes the Eastern *Sagittas* from the European as a whole is the frequency of intestinal diverticula in the neck; these are found only in one European species, but five, or more than one-third of the whole, of those from the Maldives possess them. The same fact has been noticed by Conant with regard to the American *Sagittas*, a large proportion of which have the diverticula.

The fact that so many species should be common to the Eastern coast of America and to the Indian Ocean, although not found between, is remarkable, but is probably explained by the absence of complete lists from the Southern Atlantic. When the latter area has been more carefully examined, it will probably be seen that this apparent discontinuous

distribution is not real. It is rather surprising, however, that a species like *S. hispida*, recorded from the Bahamas and the coast of the United States, and therefore in the path of the Gulf Stream, should not yet have been found in the North-eastern Atlantic.

In conclusion I wish to thank Mr C. Forster Cooper, B.A., for drawing the figures in the accompanying plate.

EXPLANATION OF PLATE XIII.

The corona ciliata has been represented as a dotted line, except in Fig. 7.

FIG. 1 *A.* *Sagitta robusta* nov. sp., outline. 1 *B.* The same, head and neck.

FIG. 2. *Sagitta ferox* nov. sp., head and neck.

FIG. 3 *A.* *Sagitta polyodon* nov. sp., outline. 3 *B.* The same, head and neck.

FIG. 4 *A.* *Sagitta pulchra* nov. sp., outline. 4 *B.* The same, head and neck.

FIG. 5 *A.* *Sagitta gardineri* nov. sp., outline. 5 *B.* The same, head and neck.

FIG. 6. *Sagitta septata* nov. sp., showing peculiar structure of the ovaries.

FIG. 7. *Sagitta regularis* Aida, showing thickened epidermis, corona, and ovaries.